FINAL REPORT

RESOLUTION COST FACTORS FOR DIMINISHING MANUFACTURING SOURCES AND MATERIAL SHORTAGES

February 1999

Prepared for
Defense Microelectronics Activity (DMEA)
4234 54th Street, Bldg. 620
McClellan AFB, CA 95652-1521

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under Contract GS-35F-4825G
Task Order DMEA90-98-F-0018

by

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ABSTRACT

The cost of resolving Diminishing Manufacturing Sources and Material Shortages (DMSMS) problems is of primary concern to Department of Defense (DoD) program managers. The DoD Executive Agent for microelectronics DMSMS, the Defense Microelectronics Activity (DMEA), is developing cost factors for various DMSMS resolutions so that DoD programs can uniformly report cost avoidance and determine the cost impact of implementing a DMSMS program. Under Contract GS-35F-4825G, task order DMEA90-98-F-0018, ARINC identified the resolutions most commonly used by DoD and developed nonrecurring engineering cost factors for each. This final report describes the approach used and presents the identified cost factors.

ACKNOWLEDGMENT

Many organizations, too numerous to mention, contributed data for this report. The authors wish to thank those who provided additional guidance and support—specifically, Wesley Trunnell from the Defense Microelectronics Activity (DMEA); Bill Johnson from Defense Supply Center Columbus (DSCC); Anna Colbert from Naval Supply Systems Command (NAVSUP); Steve Buss from Northrop Grumman Electronic Sensors and Systems Division (ESSS); Justine Corboy from Sarnoff Corporation; and Greg Kromholtz from Boeing Information, Space, and Defense Systems. These individuals and their associates helped with the critical tasks of defining resolutions and identifying the required activities for each.

EXECUTIVE SUMMARY

The cost of resolving Diminishing Manufacturing Sources and Material Shortages (DMSMS) problems is of primary concern to Department of Defense (DoD) program managers. The DoD Executive Agent for microelectronics DMSMS, the Defense Microelectronics Activity (DMEA), is developing cost factors for various DMSMS resolutions so that DoD programs can uniformly report cost avoidance and determine the cost impact of implementing a DMSMS program. These cost factors provide the average cost of resolving DMSMS problems. DMEA awarded ARINC a contract to develop these factors. ARINC identified the resolutions most commonly used by DoD and developed nonrecurring engineering cost factors for each. In addition, ARINC applied these cost factors to two models that calculated cost avoidance.

ARINC collected cost data from various sources. For each resolution, we determined three cost factors: low, average, and high. The cost factors are included in Table S-1.

Table S-1. Nonrecurring Engineering Resolution Cost Factors

Resolution	Low	Average	High
Existing Stock	$ 0	$ 0	$ 0
Reclamation	629	1,884	3,249
Alternate	2,750	6,384	16,500
Substitute	5,000	18,111	50,276
Aftermarket	15,390	47,360	114,882
Emulation	17,000	68,012	150,000
Redesign—Minor	22,400	111,034	250,000
Redesign—Major	200,000	410,152	770,000
Life of Type (LOT) buy*	-	-	-
*The LOT buy resolution is program-specific and should be calculated by the individual DoD programs.			

Before using these cost factors to determine cost avoidance, the following items should be considered:

- New source qualification could add cost; however, no standard value could be obtained because the cost could be amortized as part of recurring cost.

- If radiation hardening testing is required, the cost factors presented in Table S-1 could increase from $5,000 (dose rate only) to $52,000 (dose rate, total dose, and single-event upset) and possibly as much as $82,000 for microprocessors.

- If plastic encapsulated microcircuit testing is required, each cost factor could increase from $600 (acoustic microscopy only) to $47,340 (full qualification of a 100-piece lot).

Using the factors presented above, ARINC also determined the cost avoidance resulting from implementing a DMSMS management program. ARINC applied the cost factors to the DMEA cost avoidance methodology and the ARINC Component Obsolescence Decision Support Tool for a sample system. The resultant cost avoidance for the sample system using the DMEA methodology was $2,568,811 and $2,328,906 using the ARINC tool. It should be noted that adding recurring costs increase total cost and may change the mix of preferred resolutions.

ABBREVIATIONS AND ACRONYMS

ASIC	Application-Specific Integrated Circuit
CCA	Circuit Card Assembly
CER	Cost-Estimating Relationship
CES	Cost Element Structure
CMOS	Complementary Metal Oxide Semiconductor
DLA	Defense Logistics Agency
DMEA	Defense Microelectronics Activity
DMSMS	Diminishing Manufacturing Sources and Material Shortages
DoD	Department of Defense
DRMS	Defense Reutilization and Marketing Service
DSCC	Defense Supply Center Columbus
DUSD (L)	Deputy Under Secretary of Defense for Logistics
EIA	Electronic Industry Association
EMD	Engineering and Manufacturing Development
F3I	Form, Fit, Function, and Interface
GIDEP	Government-Industry Data Exchange Program
JSTARS	Joint Surveillance Target Attack Radar System
JTIDS	Joint Tactical Information Distribution System
LOT	Life of Type
LRE	Logistics Retrofit Engineering
NAVSUP	Naval Supply Systems Command
NRE	Nonrecurring Engineering

ABBREVIATIONS AND ACRONYMS (continued)

O&S	Operating and Support
OEM	Original Equipment Manufacturer
OSD	Office of the Secretary of Defense
PEM	Plastic-Encapsulated Microcircuit
QCI	Qualification Conformance Inspection
QML	Qualified Manufacturers List
QPL	Qualified Parts List
SEU	Single-Event Upset
TIM	Technical Interchange Meeting
UDR	Urgent Data Request

CONTENTS

CONTENTS (continued)

LIST OF TABLES

SECTION 1

INTRODUCTION

1.1 BACKGROUND

Diminishing Manufacturing Sources and Material Shortages (DMSMS) is the loss or impending loss of manufacturers or suppliers of critical items and raw materials due to discontinuance of production. DMSMS can be caused by rapid changes in item or material technology, uneconomical production requirements, foreign source competition, federal environmental or safety requirements, and limited availability or increasing cost of items and raw materials used in the manufacturing process.

DMSMS is a serious issue for the Department of Defense (DoD), the airline community, and many commercial industries. Although increased reliability has lengthened *system* life cycles, decreased demand, fewer manufacturers, and rapid advances in technology have shortened *component* life cycles from between 10 and 20 years to between 3 and 5 years. This problem is particularly acute for electronic systems but affects nonelectronic systems as well.

In the DoD, concern is growing about the costs of resolving current and future DMSMS problems. The Deputy Under Secretary of Defense for Logistics (DUSD (L)) indicates that the average cost to redesign a circuit card to eliminate obsolete components is $250,000. The Electronic Industry Association (EIA) Manufacturing Operations and Technology Committee reported a cost range for redesign of $26,000 to $2 million. The Air Force is reprogramming $81 million for the F-22 program to purchase obsolete or soon-to-be out-of-production parts and to redesign assemblies to accept commercial parts. An avionics manufacturer for the commercial airlines spent $600,000 to replace an obsolete Intel chip. The F-16 program has spent $500 million to redesign an obsolete radar. In fiscal year 1997, the KC-130F/R program spent $264,000 on a life of type (LOT) buy as a resolution for one obsolete logic device.

To minimize the impact of DMSMS, DoD activities and program offices must be able to incorporate the most timely and cost-effective resolutions to avoid costly redesign. DMSMS programs provide techniques and tools for actively managing implementation of the selected resolution. Although there is an expense to manage a DMSMS program, cost avoidance can be realized from such a program. However, the data required to uniformly report the cost avoidance associated with actively managing DMSMS have not been available. This problem was brought to light by the DMSMS cost avoidance metrics reported to the Government-Industry Data Exchange Program (GIDEP) by its members. Other than a $250,000 cost factor for circuit card redesign, GIDEP members had no factors to uniformly report DMSMS cost avoidance.

1.2 ROLE OF DMEA

The Defense Microelectronics Activity (DMEA), located in Sacramento, California, operates under the authority, direction, and control of DUSD (L). Its primary mission is to leverage the capabilities and advantages of advanced technology to solve operational problems in existing weapon systems, increase operational capabilities, reduce operating and support (O&S) costs, and reduce the effects of DMSMS. In this capacity, the DMEA assists weapon systems managers and managers of other operational or developmental systems in inserting advanced microelectronics technologies, ensuring lifetime sustainment of systems that are dependent on microelectronics and providing studies and analyses of existing or future obsolescence problems. DMEA is also the DoD Executive Agent for microelectronics DMSMS. In this role, it helps to identify microelectronics obsolescence problems and uses its logistics retrofit engineering (LRE) process to offer a comprehensive mix of solutions to these problems.

DMEA is an active member of both the DoD DMSMS Working Group and DoD DMSMS Teaming Group. DUSD (L) established the DMSMS Working Group to foster the development of DMSMS management techniques, tools, and policies to increase readiness, sustain wartime operations, and reduce life-cycle costs of DoD weapon systems. To that end, the Working Group established and chartered the DoD DMSMS Teaming Group, a formalized group of representatives from DoD programs and industry that work together to share solutions to common DMSMS problems. The Teaming Group maintains a database of current information on DMSMS and, whenever possible, explores resolutions that will work for all programs experiencing DMSMS, often reducing the cost. The DMSMS Teaming Group process is described in Appendix A.

1.3 OVERVIEW OF APPROACH

DUSD (L) recognized the need to determine cost factors for DMSMS resolutions. The cost factors will allow DoD programs to uniformly report DMSMS cost avoidance associated with implementing the best resolution in line with program requirements and cost constraints, and will be used by the DMSMS Teaming Group to report cost avoidance metrics back to GIDEP. DUSD (L) requested DMEA to develop cost factors for all DoD programs to uniformly report cost avoidance associated with their DMSMS programs. DMEA awarded ARINC a contract to develop these factors.

ARINC's primary objective was to determine the industry average costs for typical DMSMS resolutions and develop cost avoidance calculations. A secondary objective was to develop a cost element structure for additional cost elements that individual program offices may incur when implementing DMSMS resolutions. The emphasis was on active electronic devices, which are a major contributor to DMSMS problems. Passive electronic and nonelectronic devices (e.g., fuel pumps, structures, hydraulics), which are lesser contributors to DMSMS, were not addressed.

ARINC established the following ground rules and assumptions and coordinated them with DMEA at a technical interchange meeting (TIM) on January 12, 1999:

- Costs are in constant fiscal year 1999 dollars.
- Cost factors are determined for the DMSMS resolutions agreed upon at the January 12, 1999, TIM (listed in section 2.1 of this report)
- Cost factors are determined for nonrecurring engineering (NRE). (Cost factors for recurring engineering are provided in this report for reference only.)
- NRE cost factors do not include procurement and administrative labor hours (time to identify sources of supply).
- NRE cost factors do not include costs associated with developing new microcircuits using state-of-the-art technologies.
- Additional cost elements identified are addressed separately from the NRE cost factors.

ARINC collected cost data from various sources. For each resolution, we determined three cost factors: low, average, and high. We then used both the DMEA cost avoidance methodology and the ARINC Component Obsolescence Decision Support Tool to estimate cost avoidance for a sample DMSMS program.

1.4 REPORT ORGANIZATION

Section 2 of this report presents the DMSMS resolutions and cost factors and additional program-specific cost elements. Section 3 provides cost avoidance calculations for a sample program. A summary is provided in Section 4. Supporting data are provided in appendixes, as follows:

- Appendix A: An ARINC paper that describes the DoD DMSMS Teaming Group process
- Appendix B: DoD Materiel Management Regulation, 4140.1-R, Chapter 1, Section D
- Appendix C: Cost data sheets for the collected data

- Appendix D: An example cost element structure specifying additional cost elements that could be affected as a result of DMSMS

- Appendix E: A draft paper describing the ARINC Component Obsolescence Decision Support Tool

- Appendix F: Sample data output from the ARINC Component Obsolescence Decision Support Tool to determine cost avoidance

- Appendix G: An excursion on recurring cost and its influence on cost avoidance

SECTION 2

DMSMS RESOLUTIONS AND COST FACTORS

2.1 DMSMS RESOLUTIONS

Activities throughout DoD primarily use four publications for information about DMSMS resolutions:

- DoD Materiel Management Regulation, 4140.1-R, Chapter 1, Section D, January 1993
- Air Force Materiel Command DMSMS Program Case Resolution Guide, July 15, 1998
- Naval Sea Systems Command Case Resolution Procedures Guide (undated)
- MIL-HDBK-965 Acquisition Practices for Parts Management, September 26, 1996

Not all of these publications address each resolution, and names for resolutions vary. This information must be consistent for DoD programs to accurately compare cost factors. Attendees at the January 12, 1999, DMEA–ARINC TIM compared the information in the publications and developed a standard set of resolutions and definitions to be used in this analysis. DoD Regulation 4140.1-R was used as the primary reference and is included in Appendix B. Table 2-1 presents the resolutions addressed in each document; the first column lists the resolutions most commonly used and the name selected at the TIM.

Table 2-1. Comparison of DMSMS Resolutions

Selected Name	DoD 4140.1-R	Air Force	Navy	MIL-HDBK-965
Existing Stock				
Reclamation	Reclamation	Reclamation	Reclamation	
Alternate	Substitute			Alternate
Substitute	Limited Substitute	Substitute	Substitute	Substitute
Aftermarket	Aftermarket	Alternate	Aftermarket	
Emulation	Emulation	Emulation	Emulation	
Redesign	Redesign	Redesign	Redesign	
LOT Buy	LOT Buy	LOT Buy	LOT Buy	
	Existing Source	Existing Source		
	New Source	New Source	New Source	
	Redefine Mil-Spec	Redefine Mil-Spec		
	Replace System	Replace System		
	Contractor Inventory	Contractor Inventory		
	Production Warranty	Production Warranty		
	Reverse Engineering	Reverse Engineering	Reverse Engineering	

2.2 DATA COLLECTION METHODOLOGY

ARINC collected cost data for each of the identified resolutions, using five methods:

- Contacting ARINC's DMSMS customers
- Contacting the DoD DMSMS Teaming Group representatives and participants
- Initiating a GIDEP Urgent Data Request (UDR)
- Contacting members of the airlines' Future Concepts for Maintenance Working Group
- Reviewing published papers and presentations on DMSMS and cost estimating

Table 2-2 lists the data sources used. Sources that did not provide data cited two primary reasons: (1) they do not track or itemize DMSMS cost data, or (2) cost data are proprietary or sensitive and cannot be released. When we showed the sources that do not track the costs of resolving DMSMS problems the data we had gathered at the time of contact, many sources indicated that those data seemed reasonable.

Table 2-2. Data Sources

Air Portugal
Austin Semiconductor
Boeing
Brookhaven National Laboratory
Burlington Microelectronics
Defense Microelectronics Activity (DMEA)
Defense Supply Center Columbus (DSCC)
Electronic Industry Association
Harris Semiconductor
Haystack on CD-ROM
Honeywell
Insight Analytical Labs, Inc.
ISE Labs Inc.
Joint Surveillance Target Attack Radar System (JSTARS) Program Office
Joint Tactical Information Distribution System (JTIDS) Program Office
Lansdale Semiconductor, Inc.
Litton
Lockheed Martin Vought Systems
MITRE Corporation
MTS Microelectronics Inc.
Naval Air Systems Command
Naval Supply Systems Command
Northrop Grumman
Ogden Air Logistics Center (OO-ALC/LRFP)
PMA-209
Rochester Electronics
Rockwell Collins
Sarnoff Corporation
Sextant Avionique
Texas Instruments
Warner Robins Air Logistics Center

2.3 RESOLUTION COST FACTORS

ARINC analyzed the collected data and developed low, average, and high cost factors for each resolution. Table 2-3 presents the cost factors. The table also provides definitions and required activities for each resolution. The cost factors in Table 2-3 are for NRE only and do not include procurement and administrative labor costs (time to identify existing sources of supply—estimated as 1 to 32 hours of labor). Appendix C presents data sheets that provide the basis of each estimate.

ARINC also developed recurring cost multipliers (Table 2-4). These values are based on program-specific demand and are required for determining program office budgets. Recurring costs could alter the cost avoidance calculations presented in Section 3. As with the NRE cost factors, low cost multipliers are typically for low-complexity devices with high-volume procurement, where the government owns the technical data and testing requirements are minimal; high cost multipliers are for high-complexity devices with low-volume procurement, where the contractor owns the technical data and qualification testing is required.

2.4 ADDITIONAL PROGRAM-SPECIFIC COST ELEMENTS

In addition to the DMSMS resolution costs listed in Tables 2-3 and 2-4, other program-specific resolution costs are often needed. To highlight these cost areas, ARINC developed a cost element structure (CES) based on guidance provided in MIL-STD-881B and the Office of the Secretary of Defense (OSD) Cost Analysis Improvement Group (CAIG) Operating and Support Cost-Estimating Guide, May 1992. The CES is a detailed breakout of potential cost elements for any DoD program, presented according to life-cycle phase—engineering and manufacturing development (EMD), production and deployment, and operating and support. Appendix D provides the CES.

The CES developed could be used at the system level by breaking down a typical DMSMS resolution process into three phases: EMD, production, and O&S (developing a resolution, producing and incorporating the resolution, and sustainment for the resolution). ARINC analyzed each element for relevance to a typical DMSMS resolution process and noted whether the element was required to be estimated, inclusion was optional, or the element was not required based on the nature of the program. For example, element 220, production unit install schedule (i.e., quantity per year), is required in order to plan for ramp-up quantities early in a life-cycle and declining quantities late in a life-cycle.

Under certain circumstances, the resolutions identified may require any of the following actions: qualifying new sources, conducting radiation hardening tests, and conducting special tests for plastic-encapsulated microcircuits (PEMs). ARINC determined the CES elements associated with these actions and collected cost data. Tables 2-5 through 2-7 summarize these data. To ensure that data cannot be related to the source, a three-digit code was assigned for each source.

2.5 DMSMS COST-ESTIMATING RELATIONSHIPS

ARINC reviewed government and commercial cost-estimating relationships (CERs) to determine applicability to DMSMS resolution cost. Based on the government CERs from the Electronic System Center, Hanscom Air Force Base, we determined CERs for circuit board redesign (Appendix C). Commercial parametric cost models such as PRICE-M and SEER-IC provide CERs to estimate the cost of designing custom integrated circuits. These models use data such as number of pins, die size, and number of transistors. Analyses at this level are primarily suited for the development of new microcircuits and application-specific integrated circuits (ASICs).

See File "Table 2-3.pdf" for pages 2-5 and 2-6

Table 2-4. Recurring Cost Multipliers

Resolution	Low	Average	High
Existing Stock	1.0	1.0	1.0
Reclamation	Not available	Not available	Not available
Alternate	1.0	2.5	4.0
Substitute	1.6	5.8	10.0
Aftermarket	5.0	7.5	10.0
Emulation	10.0	20.0	30.0
Redesign	1,000.0	5,500.0	10,000.0
LOT Buy	Not applicable	Not applicable	Not applicable

The applicability to resolving DMSMS problems would be to develop a custom ASIC to replace obsolete components. Because this resolution would be program-specific, data were not available to determine average costs for this study. However, the following cost equation[*] could be used to determine ASIC development cost:

$$M = (1 + D)^{YR}[A + B(Size)^{H}]$$

where

M = ASIC development effort in labor months
D = average annual improvement factor
YR = current year (1984)
A = startup manpower
B = measure of productivity
Size = equivalent number of transistors
H = economy or diseconomy of scale

Details on this equation, together with estimated parameter values, can be found on the World Wide Web at http://www.cedcc.psu.edu/ee497f/rassp_57.

[*] C. Fey, "Custom LSI/VLSI Chip Design Productivity," *IEEE Journal of Solid-State Circuits*, vol. sc-20, no. 2, April 1985, pp. 555-561.

Table 2-5. New Source Qualification Cost Data

Description	As defined in the Air Force Materiel Command DMSMS Program Case Resolution Guide, verifying if a manufacturer or item meets manufacturing or item specifications in accordance with the Qualified Manufacturers List (QML) or the Qualified Parts List (QPL). Qualification costs include all costs incurred to ensure that a manufacturer complies with the specification and meets the QML and QPL criteria.
CES Elements	1.03.1.1.09, Quality Assurance Program 1.03.2.1.5, Vendor Liaison 1.03.2.1.6, Subcontractor Management
Cost Data	Program-specific—Amortization may be included as part of recurring cost (source 103)
Notes	Sources 023 and 187 provided a range of $20,000 to $161,000; however, because an entire production line can now be qualified through the QML, average costs for this category are difficult to obtain.

Table 2-6. Radiation Hardening Testing Cost Data

Description	Three parameters are typically tested for radiation hardening: *Dose Rate*: The temporary time variation effects of ionizing radiation in electronic systems. Exposure to transient radiation produces free electrons. When these charge carriers cross junctions in a semiconductor, they produce transient currents. *Total Dose*: Long-term absorption of ionizing radiation by an electronic system, causing permanent damage. Absorption can increase conductivity of semiconductors, displace dopants, and increase or decrease the potential differences within circuits. *Single-Event Upset (SEU)*: Primarily logic-upset errors that occur in high-density circuits. SEUs tend to occur randomly in time and in position within the integrated circuit. After the circuit is reset or function is recovered, tests show no degradation in the circuit characteristics, and the corresponding hardware suffers no damage.
CES Elements	1.04.1.2, Test and Evaluation 1.04.4, Test and Evaluation Support 1.04.5, Test Facilities
Cost Data	Dose rate $15,000 - $20,000 Total dose $5,000 - $12,000 Single-event upset $15,000 - $20,000 (microprocessors up to $50,000)
Notes	Sources 125, 312, and 456 provided data.

Table 2-7. Plastic-Encapsulated Microcircuit Testing Cost Data

Description	Three tests are typically conducted for PEMs: 100% screening, package qualification, and acoustic microscopy. Acoustic microscopy is a nondestructive test that will detect disbonds or delaminations between the plastic resin package material and the die, die pad, or lead frame. Acoustic microscopy is often conducted before and after 100% screening and package qualification.
CES Elements	1.04.1.2, Test and Evaluation 1.04.4, Test and Evaluation Support 1.04.5, Test Facilities
Cost Data	*Acoustic Microscopy (often conducted three times)* Per test: $ 600 – 630 × 3 hr Total: $1,800 – 1,890 *100% Screening* Test program and boards: $ 9,500 Burn-in boards and sockets: 2,000 Temp cycle (1,000 cycles): 1,500/lot Burn-in and electrical test: 2.50/unit Total (100-unit lot): $13,250 *Package Qualification** Autoclave: $ 250 – $ 750 HAST (with one board at $1k/ea.): 2,850 Bias moisture (using HAST board): 1,500 – 1,850 Temp cycle (1,000 cycles): 1,500 – 5,250 Thermal shock: 9,550 – 10,000 Preconditioning: 1,500 Destructive physical analysis: 10,000 Total: $27,150 – $32,200 *All elements with a range indicate that the test cost varies by product type.
Notes	Sources 318, 319, and 456 provided data. In some cases, 100% screening and package qualification have induced failures. Although yield loss will vary by lot, a typical loss is 10%.

SECTION 3

DMSMS COST AVOIDANCE CALCULATIONS

To determine cost avoidance resulting from implementing a DMSMS management program, ARINC applied the DMEA cost avoidance methodology and the ARINC Component Obsolescence Decision Support Tool to the JTIDS program. Both approaches required the use of the cost factors summarized in Table 3-1. (LOT buy is not included because those costs are program-specific.)

Table 3-1. NRE Resolution Cost Factors

Resolution	Low	Average	High
Existing Stock	$ 0	$ 0	$ 0
Reclamation	629	1,884	3,249
Alternate	2,750	6,384	16,500
Substitute	5,000	18,111	50,276
Aftermarket	15,390	47,360	114,882
Emulation	17,000	68,012	150,000
Redesign—Minor	22,400	111,034	250,000
Redesign—Major	200,000	410,152	770,000

3.1 DMEA METHODOLOGY

The DMEA cost avoidance methodology ranks each resolution from lowest cost to highest cost. Cost avoidance is determined by subtracting the cost of a resolution (Table 3-1) from that of the next-higher-cost resolution. Table 3-2 lists the resulting values.

Table 3-2. DMEA Cost Avoidance Values

Resolution	Low	Average	High
Existing Stock	$ 629	$ 1,884	$ 3,249
Reclamation	2,121	4,500	13,251
Alternate	2,250	11,727	33,776
Substitute	10,390	29,249	64,606
Aftermarket	1,610	20,652	35,118
Emulation	5,400	43,022	100,000
Redesign—Minor	177,600	299,118	520,000
Redesign—Major	0	0	0

ARINC analyzed resolution data from the JTIDS program. The data provide the number of times a resolution was used for a total of 181 obsolete parts. We also obtained LOT buy data specific to JTIDS. The average JTIDS LOT buy is $43,684. Using the average cost avoidance values from Table 3-2 and the JTIDS data, we determined the data summarized in Table 3-3.

Table 3-3. Cost Avoidance Estimate for JTIDS Using DMEA Methodology

Resolution	Probability of Occurrence (%)	Number of Occurrences	Average Delta	Cost Avoidance
Existing Stock	4.5	8	$1,884	$15,345
Reclamation	0.0	0	4,500	0
Alternate	68.0	123	11,727	1,443,324
Substitute	7.0	13	25,573	324,009
LOT Buy	12.0	22	3,676	33,265
Aftermarket	5.0	9	20,652	448,556
Emulation	3.0	5	43,022	233,610
Redesign—Minor	0.5	1	299,118	270,702
Redesign—Major	0.0	0	0	0
Total	100.0	181		$2,768,811

To determine cost avoidance resulting from a DMSMS program for JTIDS, we subtracted the cost of the DMSMS program from the total value of $2,768,811. Assuming a DMSMS program cost of $200,000, the resultant cost avoidance is $2,568,811. This is equivalent to the cost of approximately six major redesigns. There are two situations in which adjustments to the cost avoidance calculation would be required:

- In some instances, the next-higher-cost resolution may not be technically feasible; for example, emulation may not be a viable alternative for a complex ASIC.
- A redesign may resolve DMSMS problems for more than one (often five) components at once.

3.2 ARINC MODEL

The ARINC Component Obsolescence Decision Support Tool is primarily used by program managers to determine current and future budgets for nonrecurring and recurring DMSMS resolutions. A draft of a paper to be presented at the 1999 DMSMS Symposium provides a summary description of the tool and is provided in Appendix E.

When using the tool to determine current and future cost avoidance for a DoD program, input variables (e.g., resolution probability of occurrence, turnaround time, in-process rate) would change if a DMSMS program were not implemented. If JTIDS did not have a DMSMS program, additional redesigns would likely be required, and additional costs would be incurred. To compare the result using the ARINC tool with that using the DMEA methodology, we determined the effect if six resolutions did in fact result in a major redesign. With apportioned adjustments made to the resolution breakout from the DMEA methodology, we determined cost avoidance. Table 3-4 shows the adjustments.

Table 3-4. Adjusted Resolution Data

Resolution	With a DMSMS Program		Without a DMSMS Program	
	Probability of Occurrence (%)	Number of Occurrences	Probability of Occurrence (%)	Number of Occurrences
Existing Stock	4.5	8	4.4	8
Reclamation	0.0	0	0.0	0
Alternate	68.0	123	65.8	119
Substitute	7.0	13	6.8	12
Aftermarket	5.0	9	4.8	9
Emulation	3.0	5	2.9	5
Redesign—Minor	0.5	1	0.5	1
Redesign—Major	0.0	0	3.3	6
LOT Buy	12.0	22	11.7	21
Total	100.0	181	100.0	181

Note: Calculations may vary due to rounding.

Appendix F provides the output from the ARINC tool. The output shows a JTIDS total NRE cost for 1999 of $2,863,236 with a DMSMS program and $5,392,142 without a DMSMS program. The difference between the two values is a cost avoidance of $2,328,906. Additional cost avoidance calculations could be made for future years, using a similar method.

3.3 IMPACT OF RECURRING COST ON CALCULATIONS

The two cost avoidance techniques provide similar results for nonrecurring engineering. Recurring cost could alter these results. To demonstrate the effect of including recurring costs when estimating DMSMS cost avoidance, we compared two scenarios—one using 10 units, and one using 100 units. Results of the comparison, provided in Appendix G, show that adding recurring cost can significantly change the amount of cost avoidance for each resolution and, in some cases, can change the cost avoidance ranking of the resolutions.

SECTION 4

SUMMARY

ARINC collected cost data from various sources. For each resolution, we determined three cost factors: low, average, and high. The cost factors are included in Table 4-1.

Table 4-1. NRE Resolution Cost Factors

Resolution	Low	Average	High
Existing Stock	$ 0	$ 0	$ 0
Reclamation	629	1,884	3,249
Alternate	2,750	6,384	16,500
Substitute	5,000	18,111	50,276
Aftermarket	15,390	47,360	114,882
Emulation	17,000	68,012	150,000
Redesign—Minor	22,400	111,034	250,000
Redesign—Major	200,000	410,152	770,000
Life of Type (LOT) buy*	-	-	-
*The LOT buy resolution is program-specific and should be calculated by the individual DoD programs.			

Before using these cost factors to determine cost avoidance, the following items should be considered:

- New source qualification could add cost; however, no standard value could be obtained because the cost could be amortized as part of recurring cost.

- If radiation hardening testing is required, the cost factors presented in Table S-1 could increase from $5,000 (dose rate only) to $52,000 (dose rate, total dose, and single-event upset) and possibly as much as $82,000 for microprocessors.

- If plastic encapsulated microcircuit testing is required, each cost factor could increase from $600 (acoustic microscopy only) to $47,340 (full qualification of a 100-piece lot).

Using the factors presented above, ARINC also determined the cost avoidance resulting from implementing a DMSMS management program. ARINC applied the cost factors to the DMEA cost avoidance methodology and the ARINC Component Obsolescence Decision Support Tool for a sample system. The resultant cost avoidance for the sample system using the DMEA methodology was $2,568,811 and $2,328,906 using the ARINC tool. It should be noted that adding recurring costs increase total cost and may change the mix of preferred resolutions

DMSMS Teaming Group Process

Jerry G. Martinez, Port Hueneme Division Naval Surface Warfare Center
(AEGIS/DoD Teaming Chairman)
Jack T. McDermott, ARINC Incorporated (Joint STARS USAF/DoD Teaming Cochairman)

Prepared for
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Introduction

Component obsolescence is a fact of life for both military and commercial systems and is a continuing issue for the Department of Defense (DoD). Until recently, DoD programs were funded sufficiently to solve obsolescence problems through the engineering change proposal (ECP) process. Today, with diminishing government funds, program managers must pursue other approaches. In addition, the increased use of commercial off-the-shelf (COTS) products has shortened system life cycles and accelerated the pace of component obsolescence.

To address the issue of component obsolescence, the Deputy Under Secretary of Defense for Logistics (DUSD (L)) established the DoD Diminishing Manufacturing Sources and Material Shortages (DMSMS) Working Group. The DoD DMSMS Working Group fosters the development of DMSMS management techniques, tools, and policies to increase readiness, sustain wartime operations, and reduce life-cycle costs of DoD weapon systems. To that end, this working group established and chartered the DoD DMSMS Teaming Group.

The DoD DMSMS Teaming Group is a formalized group of representatives from DoD programs and industry that work together to share solutions to common component obsolescence problems. The Teaming Group maintains a database of current information on component obsolescence and, whenever possible, explores resolutions that will work for all programs experiencing the obsolescence problem, often reducing the cost. For example, if a specific component used by more than one program is no longer offered by either the original equipment manfacturer (OEM) or an aftermarket supplier (AMS), each affected program may determine that emulation—developing a form, fit, function, and interface (F3I) replacement—is the best resolution. Each affected program could then share the nonrecurring engineering costs equally.

Teaming Group Process

Figure 1 illustrates the DMSMS Teaming Group process. Note that the figure is not intended to illustrate any specific program's process for addressing DMSMS. In addition, the generic term *procuring activity* is used in place of government program office, contractor, depot, or any other term used to describe a program acquisition support center. The following sections describe how the DMSMS Teaming Group process works.

Receive Notice of Obsolescence

Original equipment manufacturers continually analyze technology trends and the overall business picture when deciding whether to continue producing specific components or discontinue them. When an OEM does decide to discontinue a component, it sends a notice of obsolescence to distributors; the Defense Logistics Agency (DLA); the Government-Industry Data Exchange Program (GIDEP—a Navy-managed database); other government or commercial databases; and the procuring activity for the affected programs, if known. (Often, the OEM does not know which program uses a specific component because products typically are not directly distributed from the OEM to the program.)

Provide Part Numbers to Teaming Group Database

The procuring activity may be the government program office, the development and production contractor, or the repair agency (depot) that is responsible for sustainment of the equipment in which the component is used. The procuring activity maintains a database—using the bill of materials (BOM); assemblies, programs, and indentures (API); or other databases—of all components used in the equipment. Once the procuring activity receives a notice of obsolescence—from the OEM, distributors, DLA, GIDEP, or a commercial database—it

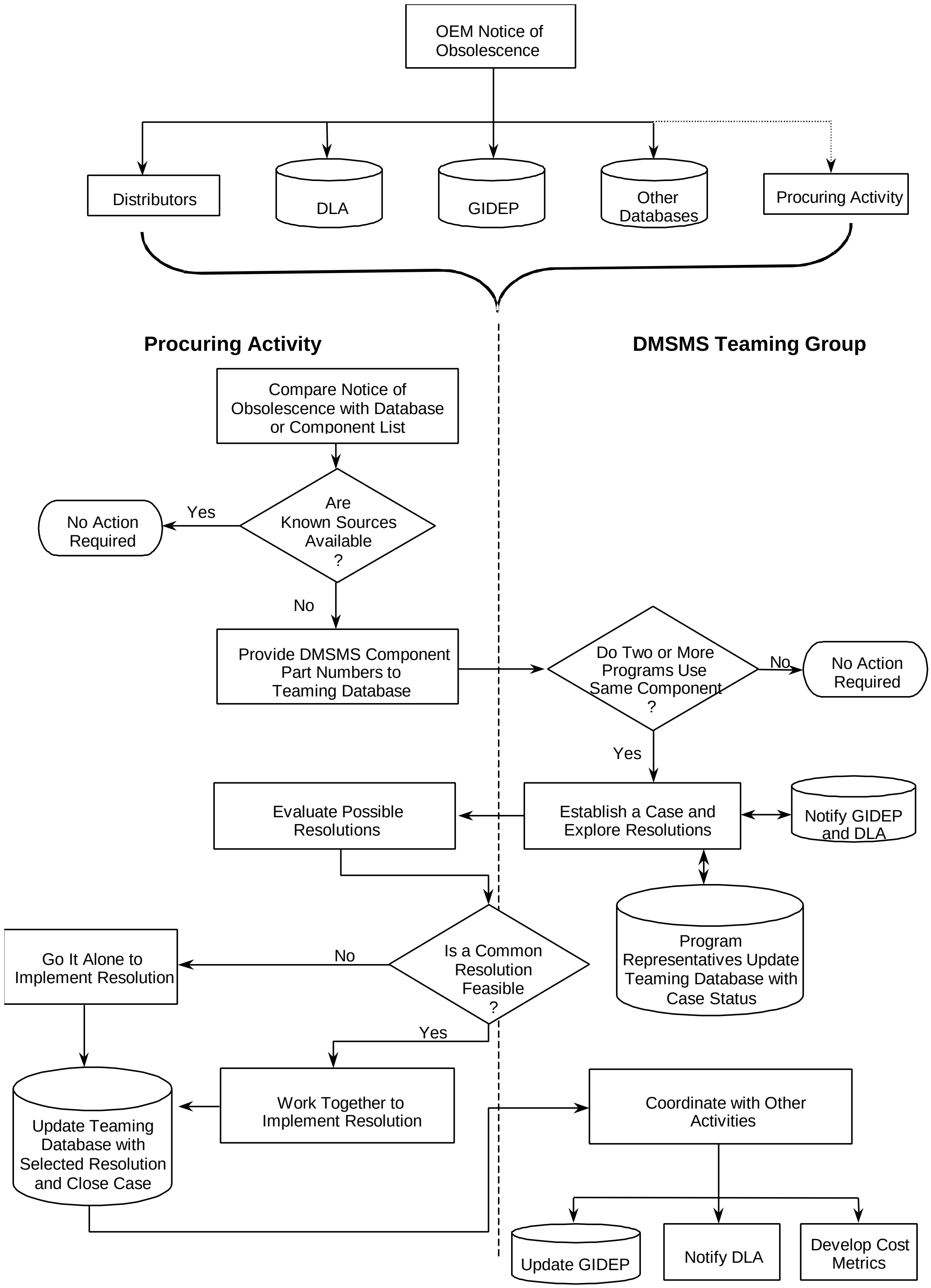

Figure 1. Overview of DMSMS Teaming Group Process

compares the notice with the database or component list to determine if the obsolete component affects production or support of any of the activity's equipment. If the component either does not affect the equipment or is still offered by at least one manufacturing source, then no action is required. However, if the equipment is affected or no known sources are available, the procuring activity provides the part number and generic part number of the obsolete component to the database maintained by the DMSMS Teaming Group. (The procuring activity may provide the part numbers to the Teaming Group Database either automatically via an activity-selected database or manually.)

Establish a Case

The DMSMS Teaming Group database continually analyzes generic part numbers of obsolete components. When two or more programs are found to use the same component (identified by generic part number), a case is established. The teaming database notifies GIDEP and the appropriate DLA Military Parts Control Advisory Group (MPCAG) supporting agency—such as Defense Supply Center Columbus (DSCC)—that a case has been established.

Explore Resolutions

The Teaming Group collects available information about the component (e.g., final order date, minimum order quantity, government inventory level) from GIDEP, DLA, and other data sources, such as primary equipment manufacturers. Based on this information, the members of the Teaming Group work together to explore possible resolutions for the case. Potential resolutions include:

- ***Aftermarket supplier***—Manufacturers sometimes buy discontinued production lines to maintain component production, or suppliers buy quantities of components that are obsolete and store them for future resale.

- ***Bridge buy***—A limited quantity of components may be purchased to satisfy near-term requirements until detailed analysis and a longer-term solution can be achieved.

- ***Continue existing sources***—Manufacturers can sometimes be encouraged to continue producing a component.

- ***Emulation***—A government or industry laboratory may have developed or have the capability to develop an F3I-compatible replacement that matches the obsolete component. One type of emulation is very-high-speed integrated circuit (VHSIC) hardware description language (VHDL) modeling, which captures the functionality of a component, shop replaceable unit (SRU), line replaceable unit (LRU), or higher assembly. VHDL modeling allows for migration to new technologies while minimizing the cost of changes in functionality.

- ***Excess assets***—It may be possible to purchase surplus obsolete components from a firm or activity that is not an aftermarket manufacturer or supplier. These components are usually left over from earlier development or production efforts.

- ***Life-of-type (LOT) buy***—The OEM, its distributors, or aftermarket suppliers may have enough inventory to meet the projected demands of the supported equipment for the rest of its operational lifetime or may continue to produce the component for a specified amount of time. (Note: Air Force Materiel Command policy AFMC-23-103 defines a LOT buy as a one-time procurement, conducted when all other cost-effective and prudent alternatives have been exhausted, for the purpose of satisfying the total future requirements of a component that will no longer be produced.)

- ***Specialty manufacturing***—Manufacturers sometimes discontinue military grade components but supply commercial grade versions. Specialty manufacturers can sometimes procure commercial dies, and package and test the finished product to military standards. Such components should never be tested or used beyond the limits specified for the original die design.

- ***Reclamation***—The component may be available from surplus inventory; from equipment that is beyond economical repair, is in deactivated or decommissioned units, or was removed as part of a modernization program; or from the Defense Reutilization and Marketing Service (DRMS). Some refurbishment or testing may be required.

- ***Redesign*** (program-specific)—The equipment may need to be redesigned to accept alternative components (e.g., a new layout of the circuit board). If no other resolution is cost-effective, a new design may be necessary to completely replace the obsolete component.

- ***Reverse engineering***—An exact replica of the component may sometimes be developed by disassembling and analyzing the component; developing design data through measurement, testing, and destructive evaluation; producing coordinate measurement machine (CMM) documentation of the component; conducting technology insertion reviews; developing and verifying technical data packages; and performing first article inspection and testing.

- ***Substitution***—It may be possible to use a similar component with an acceptable number of design differences that will not degrade the performance of the equipment.

The program representatives affected by the obsolete component enter information about various resolutions—including associated costs—into the Teaming Group database.

Select a Resolution

Each procuring activity associated with the case evaluates the Teaming Group data and selects the most appropriate resolution given program requirements and cost constraints. For example, a program that is in production mode may decide to implement a bridge buy to support its requirements until the next scheduled ECP or production block upgrade. Some considerations include:

- A program may be in multiple stages of its life cycle and therefore select multiple resolutions. For example, a program that is both in production and fielded may decide to select a LOT or bridge buy for the production resolution and emulation for the fielded resolution.

- It can be difficult to predict the life of a system. For example, the life cycle for the B-52 aircraft was originally thought to be 40 years; today, the aircraft is projected to be operational for a total of 94 years. For such systems, the procuring activity may choose emulation so that the depot does not have to invest in an indefinite amount of spare assets to support the system over its uncertain lifetime.

- A program may have a multiple number of obsolete components within a given equipment. In this case, the procuring activity may decide that redesign of the equipment may be the most cost-effective resolution.

Multiple procuring activities may consider implementing the same resolution and sharing the cost to do so. For example, if an obsolete component has not yet been emulated, they may decide that sharing the nonrecurring engineering cost of emulation is a mutually beneficial option. After making the decision to implement a specific resolution, the procuring activity updates the Teaming Group database with that information, as well as the associated cost, and closes the case.

Coordinate with Other Activities

To aid in efforts to address component obsolescence, the DMSMS Teaming Group disseminates resolution information and reports cost metrics as follows:

- ***GIDEP***—The GIDEP database is used by 1,800 members within the government and industry. GIDEP's policy is that the information in the database is updated only for those components with a posted DMSMS notification. If the resolution results in an F3I replacement, GIDEP posts the part number of the replacement. Other program-specific information, such as which next higher assemblies use an obsolete component, is not reflected in GIDEP.

- ***DLA***—The DMSMS Teaming Group provides information about selected resolutions so that DLA may help solve similar component obsolescence issues for fielded government systems. As with GIDEP, DLA is interested only in the resolution, not in information about next higher assemblies, unless DLA is the support agency. Three defense supply agencies report to DLA: Defense Supply Center Columbus, Defense Supply Center Philadelphia, and Defense Supply Center Richmond. Teaming Group information is disseminated to the agency of interest based on the federal stock supply code of the commodity.

- ***DoD Executive Agent for Integrated Circuit (IC) Microelectronics DMSMS***—The DMSMS Teaming Group provides information to the Executive Agent regarding case resolution and cost avoidance metrics. The Executive Agent uses this data to help determine DoD obsolescence trends and to assist in preparing reports and recommendations to DUSD (L) and the Deputy Under Secretary of Defense for Industrial Affairs and Installations (DUSD IA&I)).

- ***DoD DMSMS Working Group***—The Teaming Group reports cost metrics to the DoD DMSMS Working Group to provide a mechanism to measure how DMSMS affects both the military and industry.

As the DMSMS Teaming Group continues to grow, resolution information may be disseminated to additional agencies and groups.

Advantages of Joining the Teaming Group

Membership in the DMSMS Teaming Group is open to all procuring activities. Currently, no membership or computer usage fees are required.

Perhaps the most important aspect of being part of the DMSMS Teaming Group is that members are actively involved in minimizing the risk of component obsolsecence. In addition, team members:

- Expand the OEMs' knowledge of which programs use specific components

- May work together to reopen the production line for an obsolete component

- Expand their research capability (e.g., ability to identify sources or possible sources of supply)

- Benefit from the knowledge of other team members (e.g., the results of testing emulated products)

- Can share the cost of implementing a resolution

- Participate in the process of recommending DMSMS policies to DUSD (L) that affect the entire program community

- Communicate with all organizations within the Teaming Group community, including other procuring activities, DLA, GIDEP, and manufacturers

Being a member of the Teaming Group does require investment of a certain amount of time. Team members communicate via telephone conference call every two weeks and attend quarterly meetings of three to five days' duration, requiring some travel. The telephone conferences last about an hour and consist of an overview of any upcoming meetings and a review of each open case. During these phone calls, program representatives provide any new information to the team. In some cases, this information provides a way for other program representatives to solve their cases. For example, for one particular component, a program representative identified a replacement for consideration by the team. This resulted in a solution for two other affected programs.

Teaming Group members must also develop a list of obsolete component part numbers (preferably in a database) and periodically update the Teaming Group database with the resolutions selected for their procuring activity's program and with new obsolete components. Depending on what source is used to identify new obsolete components and whether the data may be electronically downloaded into the teaming database, this latter activity may not be time-intensive.

To join the DMSMS Teaming Group, a program representative should contact one of the cochairs:

Jerry Martinez, PHD NSWC (AEGIS)
Phone: 805-228-8197
Fax: 805-228-6605
E-mail:
martinez_jerry@phdnswc.nswses.navy.mil

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Phone: 781-377-6837
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E-mail: Mcdermottj@hanscom.af.mil

Upon joining, the new member must provide to the Teaming Group database a list of obsolete components and part numbers. In the case of active devices (microcircuits and semiconductors), generic part numbers are also required.

Summary

The DMSMS Teaming Group is an efficient, effective way to address component obsolescence. As budgets for procuring and support activities continue to decrease and downsizing reduces available resources, the Teaming Group becomes increasingly essential to the program community. By working together to solve DMSMS issues, DoD and industry can save both time and money. More important, by consolidating their requirements and sharing the cost of implementing resolutions, programs can realize even greater savings.

Biographies

Jerry G. Martinez manages Diminishing Manufacturing Sources and Material Shortages (DMSMS) issues for the AEGIS weapon system at the Port Hueneme Division of the Naval Surface Warfare Center. Mr. Martinez chairs the Department of Defense DMSMS Teaming Group, which consists of members from multiple Army, Air Force, and Navy programs. He has 25 years of quality assurance experience in both government and industry, as well as 9 years of technical supply support experience, and holds a bachelor's degree in business management from St. Martin's College.

John T. McDermott is a principal engineer at ARINC Incorporated, currently assigned to the Joint STARS program. In this position, he has established a DMSMS working group at Hanscom Air Force Base, Massachusetts, and is cochairman of the DoD DMSMS Teaming Group. He also is a member of the Government-Industry Data Exchange Program (GIDEP) executive management committee for DMSMS. During his 15 years with ARINC, Mr. McDermott has held various positions, including systems engineer, supporting enhancement developments and associated budgets for the DoD ATC system; task leader on the MILSTAR program; and test engineer. Previously, at Raytheon, his positions included project engineer for the Communications Systems Directorate, responsible for developing, testing, and transferring technology to manufacturing for the AN/TRC-170 Tropo program. Mr. McDermott holds an A.S. in electronics engineering from Northeastern University and a B.S. in industrial science from Fitchburg College.

APPENDIX B

DoD MATERIEL MANAGEMENT REGULATION4140.1-R, CHAPTER 1, SECTION D, JANUARY 1993

Diminishing Manufacturing Sources and Materiel Shortages (DMSMS)

A decade ago the DMSMS manager faced the dilemma of responding to out-of-production items from primarily the semiconductor industry. Concerns over the availability of passive devices or mechanical parts were almost nonexistent. However, times have changed. The rate of microelectronic discontinuances has steadily increased, and non-electronic parts obsolescence has emerged as a significant issue. In the past, the manager was in a relatively calm organizational environment and was able to react, albeit with increasing difficulty. Now we no longer have the luxury of fighting this battle from a stable platform. Acquisition reform has shaken the foundation of our organizational culture, and the traditional approaches to parts obsolescence management are no longer applicable.

1. Policy. The DoD Components will take timely and effective actions to identify and minimize the impact on DoD acquisition and logistics support efforts when a system's development, production, or post-production support capability is endangered by DMSMS.

2. Procedures

a. Each DoD Component shall designate a focal point to plan and coordinate actions to minimize the impact of DMSMS. Such actions include but are not limited to:

(1) Participating in Post Production Support planning activities conducted as part of the ILS program and documented in the Integrated Logistics Support Plan.

(2) Promoting technical efforts (such as use of emulation and generic arrays) and non-technical efforts (such as sharing Government and industry reports on DMSMS) that will neutralize or minimize DMSMS.

(3) Ensuring, to the maximum extent practical through parts screening for potential technology obsolescence, that identified DMSMS items are not included in DoD systems during design, redesign, or production. This includes screening parts for current obsolescence, and for items that may be obsolete within the near future (1 to 5 years) and assessing the vulnerability of the parts to become obsolete. If an identified DMSMS item cannot be eliminated during these stages, it is the responsibility of the procuring activity to ensure that there is continuous part availability and post-production support.

(4) Implementing the most cost-effective solution consistent with mission requirements when an item is identified as DMSMS.

(5) Conserving existing and on-order stocks by prudent challenge of suspected excessive requisitions until a cost-effective solution to the DMSMS situation can be implemented.

(6) Ensuring that there is effective communication and exchange of DMSMS information within DoD, with other Government organizations, and with industry through maximum use of: The Defense Electronic Supply Center's alerts and warnings; the Naval Avionics Center's Microcircuit Obsolescence Management (MOM) program; and the Government Industry Data Exchange Program (GIDEP). At a minimum, the information will be relative to the discontinuance of manufacturers' products and identify the item, its technical specifications, the name of the manufacturer, when the product will be discontinued, and if known, where the product is used.

b. Integrated Materiel Managers will implement the most cost-effective solution consistent with mission requirements when an item is identified as DMSMS. The following actions are considered most significant and are listed in order of preference:

(1) Encourage the existing source to continue production.

(2) Find another source. A smaller company might undertake production that no longer is profitable for a larger company.

(3) Obtain an existing substitute item that will perform fully (in terms of form, fit, and function) in place of the DMSMS item.

(4) Obtain an existing substitute item that, while it would satisfy one or more functions, might not necessarily perform satisfactorily in all of them (limited substitute).

(5) Redefine military specification (MIL-SPEC) requirements through appropriate engineering support activities, and consider buying from a commercial source. This may include MIL-SPEC tailoring. Such a course of action might induce the emergence of additional sources.

(6) Use current manufacturing processes to produce a substitute item (form, fit, function) for the unobtainable item. This emulation type technology is particularly useful in producing microcircuits. Through microcircuit emulation, inventory reduction can be achieved as obsolete items can be replaced with state-of-the-art devices which can be manufactured and supplied on demand. Emulation may be considered a more preferred alternative to 3. and 4. above, if the part may be used in a wide variety of functions.

(7) Make a Life-of-Type (LOT) buy. Based on estimated life-of-system requirements, the DoD Components may make a onetime procurement of enough material to last until the end items being supported are no longer in use. LOT buys shall include sufficient material to be provided as Government Furnished Material (GFM) for repair and for piecework applications in the procurement of additional systems, equipment, spare assemblies, and subassemblies. Before adopting this alternative, managers should take into account the potential for criticism of excessive levels of on-hand inventory.

(8) If a contractor using Government-Furnished Equipment (GFE) discontinues production, use the GFE to set up a new source.

(9) Take one of the following actions, which generally pertain to DoD Components that use the specific item and are listed in order of preference:

(a) Reclaim DMSMS parts from marginal or out-of-service equipment.

(b) Modify or redesign the end item to eliminate the part in question or replace it with another. This option may become more cost-effective if the end item contains several DMSMS parts.

(c) Replace the system in which the DMSMS item is used. This alternative would require extensive cost analysis.

(d) Require the using contractor, through contractual agreements, to maintain an inventory of DMSMS items for future DoD production demands. This option shall be weighed against the cost of the DoD maintaining an inventory and furnishing the items as GFM.

(e) Obtain a production warranty, if feasible, from the contractor to supply the item or items for a specified time (life of equipment) irrespective of demands.

(f) Transmit the information that was originally obtained from industrial sources about an actual or prospective announcement of a manufacturer’s intent to discontinue production to the cognizant IMM. This information will permit DMSMS broadcast alerts to be generated, if appropriate.

(g) Ensure that post-action surveillance is maintained by the ICP throughout the life of DMSMS items in the logistics system.

(h) Ensure that the DoD Components using the specific item respond to ICPs when requested to provide requirements information which is needed to determine the best course of action for ensuring continued supply of DMSMS items. Timeliness of these responses is essential in order to meet contractor-imposed final action deadlines.

APPENDIX C

COST FACTOR DATA SHEETS

The following pages provide supporting data for each resolution for which ARINC determined cost factors. Pricing is subject to change, so these factors should be used only as a guide. Manufacturer or supplier sales representatives should be contacted for program-unique applications or price changes. Default values noted on each cost sheet were used when data were incomplete. Note that cost calculations may vary due to rounding.

To ensure that data cannot be related to the source, a three-digit code was assigned for each source. Source codes are defined in the cover letter accompanying this report.

Resolution Name: Alternate

A. Average Cost (FY99$): $6,384

B. Required Activities and Contents: Unless otherwise noted, the nonrecurring cost includes engineering investigations, F3I part testing, and update of technical data package (TDP).

Default average values:

Labor rate	$ 70 (ARINC engineering estimate and source 020)
F3I part testing	500 (source 023)
Data	500 (source 023)

C. Range of Cost Values: $2,750 - $16,500

D. Basis of Estimate: The following sources provided NRE cost values:

Source	*NRE Cost*
188	$ 2,750 (added part testing and data costs)
120	3,400
124	3,500
020	4,710
187	5,000
124	5,600
110	6,000
023	7,624
190	10,000
160	16,500 (subtracted system testing)

Average = $6,384

Resolution Name: Substitute

A. Average Cost (FY99$): $18,111

B. Required Activities and Contents: Unless otherwise noted, the nonrecurring cost includes engineering investigations, F3I part testing, system testing, qualification conformance inspection (QCI) testing, and update of TDP. Assumes the test facility has test software, fixturing, and burn-in boards.

Additional NRE by product type if test software (SW NRE), fixtures, and burn-in boards (HW NRE) are not available (source 456):

Type	*SW NRE Cost*	*HW NRE Cost*
Linear	$ 2,000	$2,500
Memories	2,000	2,500
Digital Logic	2,000	2,500
FPGA/PLD	10,000	5,000
Processor/Controller	15,000	5,000

Default average values:

Labor rate	$ 70	(ARINC engineering estimate and source 020)
F3I part testing	2,800	(sources 021 and 124)
System testing	4,500	(sources 023 and 024)

Qualification testing per MIL-STD-883 Test Method 5005.13 (source 456):

Group A testing	$3,000
Group B testing	4,000
Group C testing	4,000
Group D testing	5,000

Data $1,000 (source 023)

C. Range of Cost Values: $5,000 - $50,276

D. Basis of Estimate:

Source	*NRE Cost*
340	$ 5,000 (crystal clock)
124	6,300
124	8,400
120	8,500
023	8,978 (comparator)
024	9,560 (bipolar IC)
340	10,000 (transistor)
190	10,250 (added 25 hours labor, system testing, and data)
023	10,819 (IC flip-flop)
023	11,164 (added QCI testing)

023	12,124 (added system testing)
023	12,171 (IC priority encoder)
187	12,500 (added system testing)
023	13,956 (hybrid)
340	15,000 (IC memory)
340	20,000 (IC gate array)
340	25,000 (hybrid)
160	28,000
340	30,000 (IC microprocessor)
020	30,240
160	35,000
024	43,320
020	50,276

Average = $18,111

Resolution Name: Emulation

A. Average Cost (FY99$): $68,012

B. Required Activities and Contents: The nonrecurring cost associated with emulating a microcircuit includes reverse engineering the original device, developing a personalized wafer, part testing, system testing, QCI testing, and update of TDP. Cost includes a minimum buy of 50 units. Does not include mixed-signal or high-voltage parts. Emulation costs for mixed-signal, high-voltage parts, and advanced technology are program-specific. The following sources provided examples of program-specific NRE cost values:

Source	*NRE Cost*
124 and 267	$ 50,000 - $300,000
023	215,796
021	223,000 (level detector) - $267,120 (line transceiver)

Default average values:

Labor rate	$ 70 (ARINC engineering estimate and source 020)
F3I part testing	3,000 (sources 021, 023, and 124)
System testing	5,375 (sources 021, 023, and 024)
QCI testing	10,000 (sources 020, 023, and 267)
Data	1,000 - $10,000 (source 023)

C. Range of Cost Values: $17,000 - $150,000

D. Basis of Estimate:

CMOS or bipolar technology, <1,000 gates, <20 volts

Source	*NRE Cost*
267	$17,000
170	20,000
020	46,700
267	47,000
123	50,000
155	55,000
021	59,225 (dial logic – added $1,000 data)
123	60,000
023	66,182 (microcircuit)
110	76,000
021	78,055 (detector – added $1,000 data)
267	97,000
123	130,000
170	150,000

Average = $68,012

Resolution Name: Reclamation

A. Average Cost (FY99$): $1,884

B. Required Activities and Contents: The nonrecurring cost includes shipping, refurbishment, and testing. In some situations, DRMS will not levy shipping charges on the program.

Default average values:

Transportation and Administration	$299 (source 455)
Refurbishment	not separately priced
Testing	$332 - $1,475 (source 455)

C. Range of Cost Values: $629 - $3,249

D. Basis of Estimate:

Source	*NRE Cost*
455 low	$ 631
455 high	1,774
124	3,249 (added transportation and admin)

Average = $1,884

Resolution Name: Redesign: Minor and Major

A. Average Cost (FY99$): $114,034 (minor); $410,152 (major)

B. Required Activities and Contents: The nonrecurring cost for redesign of a circuit board (shop replaceable unit) includes engineering, program management, integration, testing, and update of TDP.

Default values:
Based on a review of factors and cost-estimating relationships (CERs) from the Air Force Electronic Systems Command Automated Cost Estimating Integrated Tool (ACE-IT), the sum of the following factors could be used to estimate circuit card assembly (CCA) redesign cost. The factors are based on replacement cost of the end item or LRU that contains the CCA. The applicable LRU cost range for these factors is $33,550 to $1,364,000. We do not recommend using these CERs to estimate redesign costs with LRU costs (LRU$) outside this range:

Integration and assembly (I&A)	= 0.083 × LRU$
System test and evaluation (ST&E)	= 0.192 × LRU$
System engineering and project management (SE&PM)	= 0.268 × LRU$
Data (D)	= 0.087 × LRU$
CCA redesign	= I&A + ST&E + SE&PM + D

For a more accurate estimate, if ST&E costs are known, they can be added to the result of the following CER: SE&PM&D = 3.404 X LRU$^0.728

C. Range of Cost Values: $22,400 - $250,000 (minor); $200,000 - $770,000 (major)

D. Basis of Estimate:
Minor redesign (e.g., board relayout, jumper wires):

Source	*NRE Cost*
124	$ 22,400
180	26,000
180	44,000
021	73,151
021	82,852
120	100,000
170	100,000
020	123,000
124	126,000
124	175,000
160	210,000
187	250,000

Average = $110,034

Major redesign (e.g., combining functions, new board):

Source	*NRE Cost*	
217	$ 200,000	
234	250,000	
110	260,000	
155	300,000	
120	300,000	
021	308,000	
022	384,125	
187	400,000	
120	500,000	
170	500,000	
180	500,000	
110	510,000	
124	560,000	
124	770,000	
180	2,000,000	(removed as outlayer—more than 3 standard deviations from mean)

Average = $410,152

Average of all values = $260,593

Resolution Name: Aftermarket

A. Average Cost (FY99$): $47,360

B. Required Activities and Contents: The nonrecurring costs levied by an aftermarket manufacturer include packaging die, part testing, and QCI testing. Costs equal to and greater than $100,000 include the manufacture of die. Aftermarket manufacturers factor these costs into the recurring cost of the components. The costs also include a minimum buy that varies per source, ranging from 50 to 283 units.

Default values:

Labor rate	$ 70 (ARINC engineering estimate and source 020)
Die packaging	not separately priced
F3I part testing	3,000 (sources 021, 023 and 124)
System testing	5,375 (sources 021, 023, and 024)
QCI testing	10,000 (sources 020, 023, and 267)
Data	1,000 - $10,000(source 023)

C. Range of Cost Values: $15,390 - $114,882

D. Basis of Estimate:

Source	*NRE Cost*
356	$ 15,390 (added $1,000 for data and $10,000 for QCI testing)
356	17,860 (added $1,000 for data and $10,000 for QCI testing)
024	17,938 (added $10,000 for QCI testing)
310	18,650 (added $10,000 for QCI testing)
170	20,000 (added $10,000 for QCI testing)
110	24,000 (added $10,000 for QCI testing)
171	25,000 (added $10,000 for QCI testing)
186	25,786 (added $10,000 for QCI testing)
131	34,904 (added $10,000 for QCI testing)
131	34,910 (added $10,000 for QCI testing)
171	35,000 (added $10,000 for QCI testing)
170	40,000 (added $10,000 for QCI testing)
021	42,120 (added $10,000 for QCI testing)
023	46,379 (subtracted $5,000 for system testing)
186	46,600 (added $10,000 for QCI testing)
021	51,954 (added $10,000 for QCI testing)
021	53,566 (added $10,000 for QCI testing)
021	53,887 (added $10,000 for QCI testing)
020	57,125 (added $10,000 for QCI testing and subtracted $5,375 for system testing)
021	58,631 (added $10,000 for QCI testing)
170	60,000 (added $10,000 for QCI testing)

023	62,287 (subtracted $5,000 for system testing)
020	90,696
131	100,000
170	110,000 (added $10,000 for QCI testing)
023	114,882 (subtracted $5,375 for system testing)

Average = $47,360

APPENDIX D

TYPICAL COST ELEMENT STRUCTURE FOR DMSMS RESOLUTIONS

APPN	CES	DESCRIPTION	Required	Optional	Not Required
		COST SUMMARY			
	0	"SAMPLE" PROGRAM	X		
EMD	1	SAMPLE EMD PHASE	X		
PROC	2	SAMPLE PRODUCTION & DEPLOYMENT	X		
O&S	3	SAMPLE OPERATIONS & SUPPORT	X		

		PROTOTYPE REQUIREMENTS			
	110	PROTOTYPE PROCUREMENT SCHEDULE	X		
	120	PROTOTYPE INSTALL SCHEDULE	X		

		EMD PHASE			
	1	"SAMPLE" EMD PHASE	X		
	1.01	PRIME MISSION EQUIPMENT	X		
	1.01.1	NON-RECURRING	X		
	1.01.1.1	GROUP B	X		
	1.01.1.2	GROUP A-KITS		X	
	1.01.2	RECURRING			X
	1.01.2.1	GROUP B			X
	1.01.2.2	GROUP A-KITS			X
	1.02	PLATFORM INTEGRATION		X	
	1.02.1	A-KIT PROTOTYPING		X	
	1.02.2	SOFTWARE INTEGRATION (OFP)		X	
	1.03	SYS ENGINEERING / PGM MGMT	X		
	1.03.1	SYSTEMS ENGINEERING	X		
	1.03.1.1	SYSTEMS DEFINITION	X		
	1.03.1.1.01	OVERALL SYSTEM DESIGN	X		
	1.03.1.1.02	DESIGN INTEGRITY ANALYSIS	X		
	1.03.1.1.03	SYSTEM OPTIMIZATION		X	
	1.03.1.1.04	ANALYSIS OF ALTERNATIVES (AOA)	X		
	1.03.1.1.05	INTRA/INTER SYS COMPT ANAL.	X		
	1.03.1.1.06	INTRGRATION/BALANCE OF ILITIES		X	
	1.03.1.1.07	SECURITY REQUIREMENTS		X	
	1.03.1.1.08	CONFIGURATION MGMT/CONTROL	X		
	1.03.1.1.09	QUALITY ASSURANCE PROGRAM	X		
	1.03.1.1.10	VALUE ENGINEERING		X	
	1.03.1.1.11	SPECIFICATION PREPARATION		X	
	1.03.1.1.12	DESIGN OF TEST AND DEMO PLANS		X	
	1.03.1.1.13	SOFTWARE DEVEL/TEST RQMTS		X	
	1.03.1.2	SYSTEMS ENG MGMT PLAN (SEMP)		X	

	1.03.1.2.01	SPECIFICATION TREE		X	
	1.03.1.2.02	PROGRAM RISK ANALYSIS		X	
	1.03.1.2.03	SYSTEM PLANNING		X	
	1.03.1.2.04	DECISION CONTROL PROCESS		X	
	1.03.1.2.05	TECH PERFORMANCE MSURMNT		X	
	1.03.1.2.06	TECHNICAL REVIEWS		X	
	1.03.1.2.07	WORK AUTHORIZATON		X	
	1.03.1.2.08	TECH DOCUMENTATION CONTROL		X	
	1.03.1.3	RELIABILITY ENGINEERING	X		
	1.03.1.4	MAINTAINABILITY ENGINEERING		X	
	1.03.1.5	HUMAN FACTORS ENGINEERING		X	
	1.03.1.6	LOGISTICS SUPPORT ANALYSIS (LSA)		X	
	1.03.2	PROGRAM MANAGEMENT	X		
	1.03.2.1	NON-ILS PGM MGMT	X		
	1.03.2.1.1	COST, SCHEDULE & PERFORMANCE	X		
	1.03.2.1.2	WARRANTY ADMINISTRATION		X	
	1.03.2.1.3	CONTRACT MANAGEMENT	X		
	1.03.2.1.4	DATA MANAGEMENT	X		
	1.03.2.1.5	VENDOR LIAISON	X		
	1.03.2.1.6	SUBCONTRACTOR MANAGEMENT	X		
	1.03.2.2	ILS MANAGMENT	X		
	1.03.2.2.01	LSA MANAGEMENT		X	
	1.03.2.2.02	MAINT SUPPORT PLANNING		X	
	1.03.2.2.03	SUPPORT FACILITIES PLANNING		X	
	1.03.2.2.04	OTHER ILS RQMTS DETERMINATION		X	
	1.03.2.2.05	SUPPORT EQUIPMENT PLANNING		X	
	1.03.2.2.06	SUPPLY SUPPORT	X		
	1.03.2.2.07	PHS&T		X	
	1.03.2.2.08	PROVISIONING RQMTS PLANNING	X		
	1.03.2.2.09	TRAINING SYS RQMTS PLANNING		X	
	1.03.2.2.10	COMPUTER RESOURCE PLANNING		X	
	1.03.2.2.11	O,I AND D MAINT PLANNING		X	
	1.03.2.2.12	DATA MANAGEMENT	X		
	1.04	SYSTEM TEST & EVALUATION	X		
	1.04.1	DEVELOPMENT TEST & EVALUATION	X		
	1.04.1.1	PROTOTYPE INSTALL & CHECKOUT	X		
	1.04.1.1.1	A-KIT INSTALLATION		X	
	1.04.1.1.2	B-KIT INSTALLATION	X		
	1.04.1.1.3	SOFTWARE INSTALLATION		X	
	1.04.1.2	TEST & EVALUATION	X		

	1.04.2	OPERATIONAL TEST & EVALUATION		X	
	1.04.3	MOCK-UPS		X	
	1.04.4	TEST & EVALUATION SUPPORT		X	
	1.04.5	TEST FACILITIES		X	
	1.05	TRAINING		X	
	1.05.1	EQUIPMENT		X	
	1.05.2	SERVICES		X	
	1.05.3	FACILITIES		X	
	1.06	DATA	X		
	1.06.1	TECHNICAL PUBLICATIONS	X		
	1.06.2	ENGINEERING DATA	X		
	1.06.3	MANAGEMENT DATA	X		
	1.06.4	SUPPORT DATA	X		
	1.06.5	DATA DEPOSITORY	X		
	1.07	PECULIAR SUPPORT EQUIPMENT		X	
	1.07.1	TEST & MEASURING EQUIPMENT		X	
	1.07.2	SUPPORT & HANDLING EQUIPMENT		X	
	1.08	COMMON SUPPORT EQUIPMENT		X	
	1.08.1	TEST & MEASURING EQUIPMENT		X	
	1.08.2	SUPPORT & HANDLING EQUIPMENT		X	
	1.09	OPERATIONAL/SITE ACTIVATION			
	1.10	INDUSTRIAL FACILITIES			X
	1.10.1	CONSTRN/CONVRSN/XPANSN			X
	1.10.2	EQUIPMENT AQUISITN/MODRNZTN			X
	1.10.3	MAINTENANCE (INDUSTRAL FAC.)			X
	1.11	INITIAL SPARES & REPAIR PARTS	X		
PRODUCTION UNIT REQUIREMENTS					
	210	PRODUCTION UNIT PROCUREMENT SCHEDULE	X		
	220	PRODUCTION UNIT INSTALL SCHEDULE	X		
PRODUCTION & DEPLOYMENT PHASE					
	2	PRODUCTION & DEPLOYMENT	X		
	2.01	PRIME MISSION EQUIPMENT	X		
	2.01.1	NON-RECURRING			X
	2.01.1.1	GROUP B			X
	2.01.1.2	GROUP A-KITS			X
	2.01.2	RECURRING	X		
	2.01.2.1	GROUP B	X		

	2.01.2.2	GROUP A-KITS		X	
	2.02	PLATFORM INTEGRATION		X	
	2.02.1	A-KIT PROTOTYPING		X	
	2.02.2	SOFTWARE INTEGRATION (OFP)		X	
	2.03	SYS ENGINEERING / PGM MGMT	X		
	2.03.1	SYSTEMS ENGINEERING	X		
	2.03.2	PROGRAM MANAGEMENT	X		
	2.04	SYSTEM TEST & EVALUATION	X		
	2.04.1	DEVELOPMENT TEST & EVALUATION	X		
	2.04.1.1	PROTOTYPE INSTALL & CHECKOUT	X		
	2.04.1.1.1	A-KIT INSTALLATION		X	
	2.04.1.1.2	B-KIT INSTALLATION	X		
	2.04.1.1.3	SOFTWARE INSTALLATION		X	
	2.04.1.2	TEST & EVALUATION			X
	2.04.2	OPERATIONAL TEST & EVALUATION			X
	2.04.3	MOCK-UPS			X
	2.04.4	TEST & EVALUATION SUPPORT			X
	2.04.5	TEST FACILITIES			X
	2.05	TRAINI NG			X
	2.05.1	EQUIPMENT			X
	2.05.2	SERVICES			X
	2.05.3	FACILITIES			X
	2.06	DAT A	X		
	2.06.1	TECHNICAL PUBLICATIONS	X		
	2.06.2	ENGINEERING DATA	X		
	2.06.3	MANAGEMENT DATA	X		
	2.06.4	SUPPORT DATA	X		
	2.06.5	DATA DEPOSITORY	X		
	2.07	PECULIAR SUPPORT EQUIPMENT			X
	2.07.1	TEST & MEASURING EQUIPMENT			X
	2.07.2	SUPPORT & HANDLING EQUIPMENT			X
	2.08	COMMON SUPPORT EQUIPMENT			X
	2.08.1	TEST & MEASURING EQUIPMENT			X
	2.08.2	SUPPORT & HANDLING EQUIPMENT			X
	2.09	OPERATIONAL/SITE ACTIVATION			X
	2.09.1	SYS ASSY, INSTALL & CHECKOUT			X
	2.09.2	CONTRACTOR TECHNICAL SUPPORT			X
	2.09.3	SITE CONSTRUCTION			X
	2.09.4	ACFT CONVERSION			X

	2.09.4.1	A-KIT INSTALL & CHECKOUT			X
	2.09.4.2	OFP INSTALL & CHECKOUT			X
	2.1	INDUSTRIAL FACILITIES			X
	2.10.1	CONSTRUCTN/CONVERSN/XPANSION			X
	2.10.2	EQUIPMENT AQN/MDRNZTN			X
	2.10.3	MAINTENANCE (INDUSTRAL FAC.)			X
	2.11	INITIAL SPARES & REPAIR PARTS			X

		OPERATING & SUPPORT			
	3	OPERATING & SUPPORT			
	3.01	MISSION PERSONNEL			X
	3.01.1	OPERATIONS			X
	3.01.2	MAINTENANCE			X
	3.01.2.1	O-LEVEL MAINT PERSONNEL			X
	3.01.2.2	I-LEVEL MAINT PERSONNEL			X
	3.01.2.3	ORDANCE MAINT PERSONNEL			X
	3.01.2.4	OTHER MAINT PERSONNEL			X
	3.01.3	OTHER MISSION PERSONNEL			X
	3.01.3.1	UNIT STAFF PERSONNEL			X
	3.01.3.2	SECURITY PERSONNEL			X
	3.02	UNIT-LEVEL CONSUMPTION	X		
	3.02.1	POL/ENERGY CONSUMPTION			X
	3.02.2	CONSUMABLE MAT/REPAIR PARTS	X		
	3.02.2.1	MAINTENANCE MATERIAL	X		
	3.02.2.2	OPERATIONAL MATERIAL	X		
	3.02.2.3	MISSION SUPPORT SUPPLIES	X		
	3.02.3	DEPOT-LEVEL REPARABLES	X		
	3.02.4	TNG MUNITIONS/EXPENDBLE STORES			X
	3.02.5	OTHE R		X	
	3.03	INTERMEDIATE MAINT (EXT. TO UNIT)	X		
	3.03.1	MAINTENANCE	X		
	3.03.2	CONSUMABLE MAT/REPAIR PARTS	X		
	3.03.3	OTHE R		X	
	3.04	DEPOT MAINTENANCE	X		
	3.04.1	OVERHAUL/REWORK	X		
	3.04.2	OTHE R	X		
	3.05	CONTRACTOR SUPPORT		X	
	3.05.1	INTERIM CONTRACTOR SUPPORT		X	

	3.05.2	CONTRACTOR LOGISTICS SUPPORT		X	
	3.05.3	OTHE R		X	
	3.06	SUSTAINING SUPPORT	X		
	3.06.1	SUPPORT EQUIP. REPLACEMENT			X
	3.06.2	MOD KIT PROCUREMENT/INSTALL		X	
	3.06.3	OTHER RECURRING INVESTMENT		X	
	3.06.4	SUSTAINING ENGINEERING SUPPORT		X	
	3.06.5	SOFTWARE MAINTENANCE SUPPORT		X	
	3.06.6	SIMULATOR OPERATIONS		X	
	3.06.7	OTHE R		X	
	3.07	INDIRECT SUPPORT		X	
	3.07.1	PERSONNEL SUPPORT		X	
	3.07.2	INSTALLATION SUPPORT		X	

APPENDIX E

ARINC COMPONENT OBSOLESCENCE DECISION SUPPORT TOOL

(Draft Paper for the 1999 DMSMS Symposium)

ARINC OBSOLETE COMPONENTS COST DECISION SUPPORT TOOL

BACKGROUND

All programs (commercial or military) during the phases of development, production, and sustainment are affected by component obsolescence. Components go through six life-cycle phases consisting of emergence, growth, maturity, decline, phase out, and finally discontinuance (or obsolescence). The typical life-cycle phases of a component are shown in Figure 1. Each type of component will progress through the life-cycle at a different rate. Some items can stay

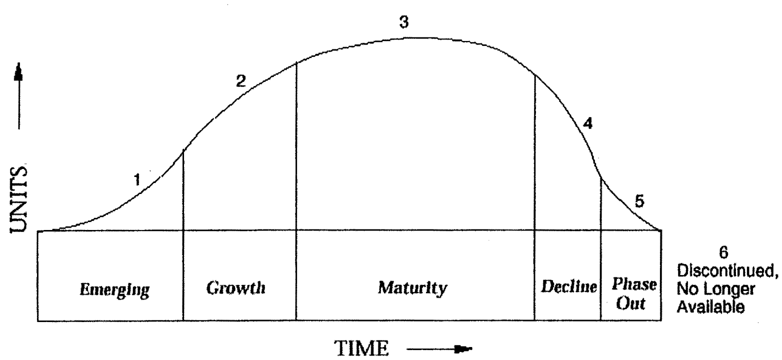

Figure E-1. Life-cycle Phases

in the same phase (for example maturity for the next six years) while one in growth may become obsolete next year. Obsolete components management database tools are available that can identify exactly what components are obsolete today. If a systems bill of material (parts list) is entered into an obsolete components management database, the obsolete components will be identified and an overall assessment of the system can be obtained.

Three popular databases are available – Government Information Data Exchange Program (GIDEP), Manufacturing Technology Incorporated (MTI), and Transition Analysis of Component Technology (TACTech). These databases provide information on how many components are obsolete today. The two commercial databases from MTI and TACTech, also provide valuable design planning data for specific obsolete components and provide a predicted assessment of the obsolescence vulnerability of the component. The ARINC Obsolete Components Modeling Technique only uses the tools to identify the parts that are known to be obsolete (or soon to be obsolete[*]) today. Once identified, the next concern is the program costs to solve these obsolete component problems.

[*] "soon to be obsolete" implies that a manufacturer has posted a last time order or buy date.

To determine the cost of obsolescence for a program, the resolution costs for each obsolete item must be determined. Figure 2 illustrates a process to determine the best resolution in-line with

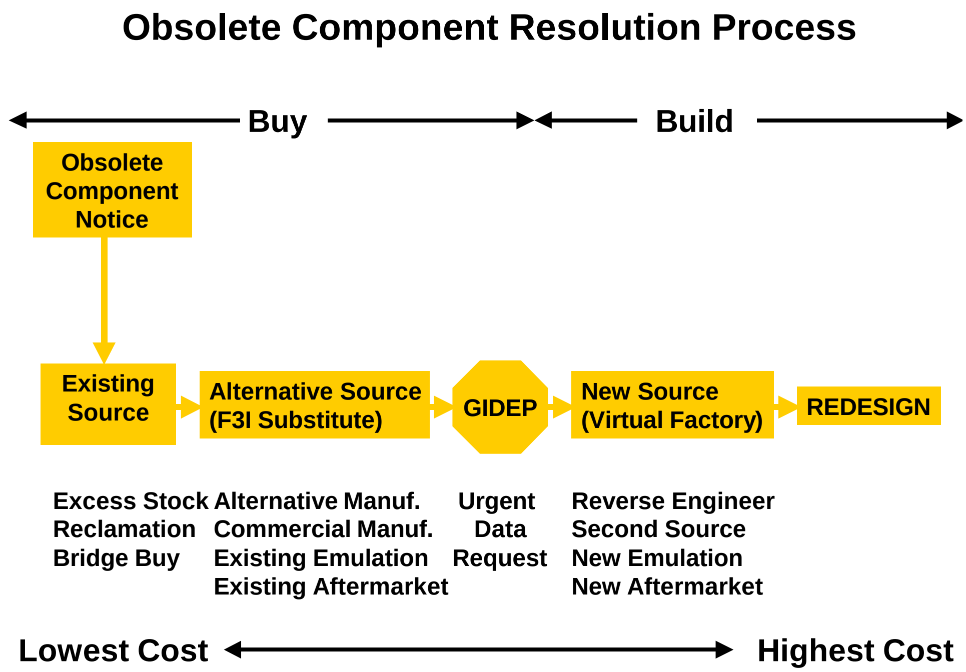

Figure E-2. Obsolete Component Resolution Process

performance and cost requirements. Typically, solution costs range from a low of only additional buys of the component, to a high of redesign activities. For budgeting exercises, program managers and manufacturers need to quantify the total life-cycle cost of each current and future obsolete component. Program managers also need to show the cost avoidance associated with implementing a component obsolescence program.

DESCRIPTION OF MODEL

To determine the cost of obsolescence for a system, four basic questions need to be answered:

1. How many items (or components) are currently obsolete?
2. How many types of components will become obsolete next year and in subsequent years?
3. How much does it cost to solve a problem for the obsolete components?
4. How many failed components will be obsolete?

If a system does not have an obsolete components database established, or if unexpected changes in demand or technology change the rate at which the components become obsolete, the ARINC components obsolescence cost modeling technique can be used. The ARINC Technique uses the database tools to identify components that are currently obsolete. To predict future obsolete components, ARINC uses basic process modeling techniques. To determine cost avoidance, the affects of more costly resolutions are modeled by changing the input variables discussed below.

To answer the first question, to determine how many components are currently obsolete, the ARINC obsolete components cost modeling technique uses inputs from any of the three popular obsolete components management database tools. To validate the results, at least two database tools are used to review the entire bill of material (parts list) or an unbiased, random sample of components. An unbiased, random sample of components is used if a system does not have the entire bill of material loaded into an obsolete component management database. A fully populated database is recommended; however, it will expedite the obsolete components resolution process, because obsolete components are identified as soon as a manufacturer provides a notification.

To answer the second question, how many types of components will be obsolete next year and in subsequent years, basic process modeling is used. The average arrival rate (induction rate) of components into a process during some "period" is observed. The average time-in-process (turn around time) is also observed for each type of component. Then if the process is in steady state (arrival rate = departure rate) the number of items in process remains at a steady state average.

Suppose we have a steady state process, except this time we do not know the induction rate (IR). We can observe the number generally in process (IP) during the period and we can estimate the turn around time (TAT). Then in this case we can solve for IR. Applying this process modeling to obsolescence we can obtain the current IP from the analysis. The estimated TAT is obtained, preferably from historical data on the system, then we solve for the current IR. For future estimates, the TAT will most likely change. Certainly, any changes in TAT will not affect the arrival rate of items (IR) but it will affect the number in process (IP). This modeling will provide us the number of obsolete components next year and in subsequent years.

The answer to the third question, how much will it cost to solve a problem, is based on collecting historical data for the system or a similar system. For each resolution (e.g., substitution, aftermarket manufacture, emulation, redesign), we obtain the probability of occurrence of each type; the historical non-recurring lower bound, most likely, and upper bound cost, and the historical recurring lower bound, most likely, and upper bound cost multiplying factors. The average unit cost of each component is also obtained. The non-recurring engineering (NRE) cost to find a solution is based on two variables: the resolution percent and historical non-recurring cost. The recurring engineering (REC) cost to implement the solution to all of those components is based on three variables – the resolution probability, historical recurring cost multiplying factor, and the average unit cost. Every problem with an obsolete component will have some non-recurring engineering applied ranging from a few hours to find a component in inventory to a year or more of redesign effort. The fourth question must be answered to determine how many components receive the recurring cost multiplying factor.

Answering the fourth question, how many failed components will be obsolete, begins with a review of system maintenance over a period of time. First maintenance actions are reviewed to determine if there is a decreasing, increasing, or constant failure rate. Then the cause of maintenance actions is determined. Historically, not all maintenance actions result in a component replacement[†] or failure. The other incidents could be can not duplicates (no-fault found), or due to connection or mechanical failure. Finally, the product of maintenance actions, percentage of maintenance actions due to component failures, and probability of the component being obsolete yields the estimated demand of which to apply the recurring cost factor.

SUMMARY

The ARINC Component Obsolescence Decision Support Tool uses a structured, step by step approach, incorporating data from existing databases for managing obsolete component problems, historical resolution and cost data, and failure data. The technique can be applied to any system, even if the entire bill of material is not yet available in a database. Changes in the mix of resolutions or turn around time can be used to model cost avoidance. Because it is a structured technique, it can also be used to estimate the cost associated with obsolete non-electronic components.

[†] Both Pecht, Michael "Handbook of Electronic Package Design" pp 254-255 and Gonzalez, Charles "1991 Proceedings Annual Reliability and Maintainability Symposium" pp 149-160 indicate that only 30% are due to components.

APPENDIX F

COST AVOIDANCE OUTPUT

JTIDS Resolution Cost Data	With DMSMS Program			Without DMSMS Program		
	1999			1999		
DMS Input Data	**Lower Bound**	**Most Likely**	**Upper Bound**	**Lower Bound**	**Most Likely**	**Upper Bound**
Total Number of Active Devices	1188	1188	1188	1188	1188	1188
Obsolescence (%) Not Resolved	15.2%	15.2%	15.2%	15.2%	15.2%	15.2%
NOPs - Num. Obsoles. Parts In-Process	181	181	181	181	181	181
TAT - Turnaround Time (Years)	2.00	2.00	2.00	2.00	2.00	2.00
NOIs - Num. Obsol. Parts Inducted	91	91	91	91	91	91
Average Unit Cost ($)	$ 20.00	$ 40.00	$ 50.00	$ 20.00	$ 40.00	$ 50.00
JTIDS Customer Specific Quantities	364	364	364	364	364	364
JTIDS Total Terminals	364	364	364	364	364	364
Specific Terminals / Total Terminals	100%	100%	100%	100%	100%	100%
Commonality Factor	84%	84%	84%	84%	84%	84%
Combined Factor	84%	84%	84%	84%	84%	84%
Demand	419	419	419	419	419	419
NODs - Num. Obsol. Parts w/ Demand	64	64	64	64	64	64
Resolution Breakout (%)	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
- Excess Stock	4.5%	4.5%	4.5%	4.3%	4.3%	4.3%
- Reclamation	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
- Alternate	68.0%	68.0%	68.0%	65.6%	65.6%	65.6%
- Substitute	7.0%	7.0%	7.0%	6.8%	6.8%	6.8%
- Aftermarket (Repackage)	5.0%	5.0%	5.0%	4.8%	4.8%	4.8%
- Aftermarket (Remanufacture)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
- Lot Buy	12.0%	12.0%	12.0%	11.6%	11.6%	11.6%
- Emulation	3.0%	3.0%	3.0%	2.9%	2.9%	2.9%
- Redesign (minor)	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
- Redesign (major)	0.0%	0.0%	0.0%	3.5%	3.5%	3.5%
NRE$FAC - JTIDS Total	**$ 6,731**	**$ 15,815**	**$ 32,786**	**$ 13,577**	**$ 29,782**	**$ 58,884**
NRE$FAC - JTIDS Specific	**$ 5,627**	**$ 13,221**	**$ 27,409**	**$ 11,351**	**$ 24,898**	**$ 49,227**
- Reclamation	$ 629	$ 1,884	$ 3,249	$ 629	$ 1,884	$ 3,249
- Alternate	$ 2,750	$ 6,384	$ 16,500	$ 2,750	$ 6,384	$ 16,500
- Substitute	$ 12,124	$ 18,111	$ 50,276	$ 12,124	$ 18,111	$ 50,276
- Aftermarket (Repackage)	$ 15,390	$ 47,360	$ 114,882	$ 15,390	$ 47,360	$ 114,882
- Aftermarket (Remanufacture)	$ 15,390	$ 47,360	$ 114,882	$ 15,390	$ 47,360	$ 114,882
- Lot Buy	$ 21,842	$ 43,684	$ 54,605	$ 21,948	$ 43,896	$ 54,870
- Emulation	$ 17,000	$ 68,012	$ 150,000	$ 17,000	$ 68,012	$ 150,000
- Redesign (minor)	$ 22,400	$ 111,034	$ 250,000	$ 22,400	$ 111,034	$ 250,000
- Redesign (major)	$ 200,000	$ 410,152	$ 770,000	$ 200,000	$ 410,152	$ 770,000
REC$FAC - JTIDS Specific	**1.9**	**3.8**	**5.7**	**19.5**	**39.0**	**76.2**
- Excess Stock	1.0	1.0	1.0	1.0	1.0	1.0
- Reclamation	1.0	1.0	1.0	1.0	1.0	1.0
- Alternate	1.0	2.5	4.0	1.0	2.5	4.0
- Substitute	0.5	1.0	2.0	0.5	1.0	2.0
- Aftermarket (Repackage)	5.0	5.0	5.0	5.0	5.0	5.0
- Aftermarket (Remanufacture)	10.0	10.0	10.0	10.0	10.0	10.0
- Lot Buy	1.0	1.0	1.0	1.0	1.0	1.0
- Emulation	10.0	20.0	30.0	10.0	20.0	30.0
- Redesign (minor)	100.0	200.0	300.0	100.0	200.0	300.0
- Redesign (major)	500.0	1,000.0	2,000.0	500	1000	2000
Total JTIDS Cost	**$ 1,221,163**	**$ 2,872,911**	**$ 5,954,083**	**$ 2,483,158**	**$ 5,491,855**	**$ 10,904,439**
- NRE Old	1,218,696	2,863,236	5,935,951	2,458,183	5,392,142	10,660,996
- NRE New						
- REC	$ 2,467	$ 9,675	$ 18,132	$ 24,975	$ 99,713	$ 243,442
- REC DMSMS Management						
JTIDS Specific Customer Cost	**$ 1,221,297**	**$ 2,603,340**	**$ 5,180,587**	**$ 2,080,016**	**$ 4,607,543**	**$ 9,156,035**
- NRE Old	$ 1,018,830	$ 2,393,665	$ 4,962,455	$ 2,055,041	$ 4,507,830	$ 8,912,593
- NRE New						
- REC Old	$ 2,467	$ 9,675	$ 18,132	$ 24,975	$ 99,713	$ 243,442
- REC New						
- REC DMSMS Management	$ 200,000	$ 200,000	$ 200,000			

APPENDIX G

RECURRING COST EXCURSION

To demonstrate the cost avoidance effects of including recurring costs when estimating the cost of alternative DMSMS resolutions, ARINC compared two scenarios. This comparison showed that adding recurring cost can significantly change the amount of cost avoidance for each resolution and, in some cases, can change the cost avoidance ranking of the resolutions.

For the comparison, ARINC used the following assumptions:

- For both scenarios, the average unit price of an active device is $50.
- The quantity of units is 10 for scenario 1 and 100 for scenario 2.
- Recurring cost multiplying factors are applied to each resolution. These factors are based on complexity and ease of implementation of the resolution. The recurring cost multiplying factors are as follows:

Resolution	*Factor*
Substitute	2.5
Substitute with Screening	5.8
Aftermarket (Repackage)	5.0
Aftermarket (Remanufacture)	10.0
Emulation	20.0
Redesign	5,500.0

Table G-1 shows the results for scenario 1. For 10 units, including recurring costs increases the cost avoidance for aftermarket remanufacture from $0 to $5,000, and for emulation from $277,000 to $3,017,000. Table G-2 shows that, for scenario 2 with 100 units, including recurring costs decreases the cost avoidance for substitute with screening from $7,000 to $3,000.

Table G-1. Scenario 1

Scenario 1: Quantity of 10 Units, Adding Recurring Changes Cost Avoidance					
	NRE		Recurring	Recurring + NRE	
Resolution	Cost	Cost Avoidance	Cost	Total Cost	Cost Avoidance
Substitute	$1,250	$1,750	$1,250	$2,500	$3,400
Substitute with Screening	$3,000	$7,000	$2,900	$5,900	$6,600
Aftermarket (Repackage)	$10,000	$12,500	$2,500	$12,500	$15,000
Aftermarket (Remanufacture)	$22,500	$0	$5,000	$27,500	$5,000
Emulation	$22,500	$277,500	$10,000	$32,500	$3,017,500
Redesign	$300,000		$2,750,000	$3,050,000	

Table G-2. Scenario 2

Scenario 2: Quantity of 100 Units, Adding Recurring Changes Cost Avoidance					
	NRE		Recurring	Recurring + NRE	
Resolution	Cost	Cost Avoidance	Cost	Total Cost	Cost Avoidance
Substitute	$1,250	$1,750	$12,500	$13,750	$18,250
Substitute with Screening	$3,000	$7,000	$29,000	$32,000	$3,000
Aftermarket (Repackage)	$10,000	$12,500	$25,000	$35,000	$37,500
Aftermarket (Remanufacture)	$22,500	$0	$50,000	$72,500	$50,000
Emulation	$22,500	$277,500	$100,000	$122,500	$27,677,500
Redesign	$300,000		$27,500,000	$27,800,000	